

Long-term fertilizer experiment on soil properties and yield parameters of rice on Chromustert

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ABSTRACT

A long term experiment was conducted with the objective of assessing the impact of continuous application of chemical fertilizers and manures on properties of soil, key indicators of soil quality and yield under rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. The experiment was conducted in randomized block design since 1999 on vertisols at the same site and with the same randomization at Raipur in central India as one of the centers of AICRP on long-term fertilizer experiment. Results showed that application of 150 per cent NPK recorded highest yield (5.06 tons/ha) which was on par with 100 per cent NPK + FYM treatment (4.85 tons/ha). The soil pH and EC were not changed but the organic carbon, available nutrient contents of the soil and plant growth parameters were markedly changed.. The available N, P and K were gradually depleted in all the treatments but the magnitude of depletion was less in the treatments which received N, P and K. Thus the balanced use of fertilizers continuously either alone or in combination with organic manure is necessary for sustaining soil fertility and productivity of rice crop.

Keywords: Rice; wheat; soil; chemical fertilizers; manures; cropping system

INTRODUCTION

Organic manure plays a vital role in sustaining higher productivity in intensive agriculture and irrigated rice in particular. The availability of organic manures like farmyard manure (FYM), green manure (GM) and blue-green algae (BGA) is however a major limiting factor for its use. Integrated nutrient management is one of the most important components of production technology to sustain fertility and crop productivity. The combined use of organic and inorganic sources of plant nutrients not only pushes the production and profitability of field crops but also maintains the fertility status of the soil. The advantage of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately (Palaniappan and Annadurai 2007).

Indiscriminate use of high analysis chemical fertilizers results in deficiency of nutrients other than the ones applied and causes decline in the organic

carbon content (Singh et al 1999). The objective of present study was to observe the effect of continuous application of fertilizers and manures on yield, uptake and nutrient availability of rice under rice-wheat cropping system in Chromustert.

MATERIAL and METHODS

A long-term experiment effect of organic and inorganic nutrients on rice had been in progress since 1999 at Research farm in IGKV, Raipur, Chhattisgarh. The present investigations were carried out during the Kharif season of 2013 on vertisol after 14 years of this experimentation in the same field. The experiment involved 10 treatments each replicated four times in a randomized block design. The experiment was conducted on the same site with same randomization. The nutrients were applied through inorganic fertilizers like urea, single super phosphate, muriate of potash and zinc sulphate; organic fertilizers like FYM, GM and BGA. The general properties of surface soil were pH 7.7, EC 0.20 dS/m, organic carbon 6.2 g/kg,

available N 236.1 kg/ha, available P_2O_5 16 kg/ha and available K_2O 474 kg/ha. Soil samples were collected from 0 to 15 cm soil depth after harvesting of rice in 2013 at the end of fifteenth cropping cycle of the crop. Soil pH, EC and organic carbon were estimated by Jackson (1973), Richards et al (1954) and Walkley and Black wet oxidation method (Walkley and Black 1934). The available nitrogen was determined by alkaline permanganate method (Subbaiah and Asija 1956), phosphorus by Olsen's method (Olsen et al 1949) and available potassium by the method of Jackson (1973).

RESULTS and DISCUSSION

Data on the effect of continuous application of fertilizers and manure on of soil are given in Tables 1 to 3.

Physico-chemical properties of soil (Table 1)

Soil pH: The pH of the soil was not statistically influenced by different treatments. The pH ranged from 7.6 to 7.3. The highest (7.6) value was recorded in 100 per cent NPK + FYM whereas the lowest (7.3) value was recorded in 50 per cent NPK + FYM. A slight decrease in soil pH was observed in all the treatments as compared to the initial (7.7) value studied during the starting of the experiment in the year 1999. This can be ascribed to the acidifying effect of acids during decomposition of organics. The results are supported by the findings of Parvathi et al (2013).

Electrical conductivity: The electrical conductivity (EC) of the soil was not significantly influenced by different treatments. EC ranged from 0.17 to 0.21 dS/m. The highest (0.21 dS/m) EC was recorded in 50 per cent NPK + GM and the lowest (0.17 dS/m) in the treatment 50 per cent NPK. The trend of variation in EC of soil between the treatments was almost negligible and statistically non-significant. The observations are supported by the work of Parvathi et al (2013).

Organic carbon: Organic carbon plays an important role in maintaining soil health and its increase during the period of experimentation showed that use of fertilizers contributed in improving the soil health. The highest (0.66%) value was observed in 100 per cent NPK + FYM-treated plot followed (6.5%) by 150 per cent NPK-treated whereas the lowest (4.4%) was observed in control. The findings are in line with those of Antil et al (2011) and Tiwari et al

(2002). This indicates that if fertilizer use is integrated with manure, substantial improvement in soil health can be expected.

Plant growth parameters (Table 2)

Plant height: Significant effect of different treatments was there on height of rice crop. Application of 100 per cent NPK + FYM recorded the highest plant height at all stages of rice growth (45, 75 and 105 DAT) which was at par with 150 per cent NPK but significantly superior to control. The combined use of organic and inorganic sources of plant nutrients in varying proportions resulted in better growth of the plants. This could be due to integration of bio-fertilizer and organic manure along with chemical fertilizers which resulted in better mineralization of plant nutrients and coping better with the plant demand (Thakur and Kanwar 1994).

Panicle length and number of grains: Different treatments of fertilizers and manure showed significant variations in respect of panicle length and number of filled grains per panicle. Maximum panicle length (22.18 cm) and more (123) number of grains per panicle were noted in 100 per cent NPK + FYM which was found significantly higher than that under control and completely chemically fertilized plot but remained at par with 50 per cent NPK + GM and 50 per cent NPK + BGA.

Test weight: Data on test weight showed non-significant variation among the different treatments. The highest test weight of grains was recorded in 100 per cent NPK + FYM (32.82 g) followed by 150 per cent NPK (32.50 g) and lowest value was recorded in control (31.10 g). Yang et al (2004) reported that 1000-grain weight was increased by the application of chemical fertilizers along with organic manure.

Available nutrient status (Table 3)

Available nitrogen: Available nitrogen in soil differed significantly. It was maximum in 100 per cent NPK + FYM treatment and the minimum in control. The minimum increase was in chemical fertilizer applied treatment followed by integrated treatments.

The lower available nitrogen in control plot (167 kg/ha) could be a result of mining of available nitrogen with continuous cropping without fertilization over a

Table 1. Effect of continuous application of fertilizers and manure on physico-chemical properties of soil

Treatment	pH	EC (dS/m)	Organic carbon (%)
Control	7.4	0.18	0.44
50% NPK	7.4	0.17	0.58
100% NPK	7.5	0.18	0.63
150% NPK	7.4	0.20	0.65
100% NPK + Zn	7.5	0.20	0.55
100% NP	7.5	0.20	0.54
100% N	7.4	0.19	0.45
100% NPK + FYM	7.6	0.20	0.66
50% NPK + BGA	7.4	0.20	0.58
50% NPK + GM	7.3	0.21	0.61

Table 2. Effect of integrated plant nutrient management on growth parameters of rice

Treatment	Plant height (cm) at DAT			Panicle length (cm)	Test weight (g)
	45	75	105		
Control	49.06	77.76	83.6	18.19	31.10
50% NPK	56.98	83.02	97.9	19.99	32.15
100% NPK	63.62	97.06	103.22	21.11	32.22
150% NPK	67.85	98.59	105.5	20.64	32.50
100% NPK + Zn	63.68	93.58	104.48	20.95	32.14
100% NP	62.68	95.48	99.48	20.42	32.12
100% N	53.48	82.85	97.77	20.46	31.92
100% NPK + FYM	68.37	102.87	112.8	22.18	32.82
50% NPK + BGA	56.98	90.92	102	20.70	31.76
50% NPK + GM	61.81	96.65	104.04	20.94	33.13

DAT= Days after transplanting

Table 3. Long-term effect of various treatments on soil available nutrient status

Treatment	Available nutrients (kg/ha)		
	N	P	K
Control	167.07	8.91	360.752
50% NPK	189.53	20.82	380.744
100% NPK	217.19	29.04	392.28
150% NPK	240.88	31.42	411.85
100% NPK + Zn	201.56	28.89	387.68
100% NP	202.45	28.13	373.01
100% N	208.3	8.30	359.29
100% NPK + FYM	241.10	30.05	412.74
50% NPK + BGA	185.99	19.12	386.4
50% NPK + GM	217.85	21.23	382.14

long period of time. Increase in available nitrogen with organics is attributed to its direct addition through organics as FYM, green manure and blue-green algae contained 241.10, 218 and 186 kg/ha available nitrogen respectively. The favorable soil conditions viz organic carbon, porosity, water holding capacity etc might have

helped in the mineralization of soil nitrogen leading to its build up.

Available phosphorus: Available phosphorus in soil in different treatments differed significantly. The 150 per cent NPK treatment recorded significantly higher

available phosphorus as compared to its value in other treatments. The 100 per cent NPK + FYM treatment also recorded significantly higher available phosphorus than control and other treatments. The 150 per cent NPK and 100 per cent NPK + FYM treatments registered 278 and 262 per cent higher available phosphorus than control.

Build up of available phosphorus with the application of NPK fertilizers alone or in conjunction with organics might be due to the release of organic acids during decomposition which in turn helped in releasing phosphorus through solubilizing action of native phosphorus in the soil (Gupta et al 2006, Singh et al 2007, Urkurkar et al 2010).

Available potassium: Available potassium in soil differed significantly. It was maximum in 100 per cent NPK + FYM and minimum in control treatment. Available potassium content in all treatments decreased from its initial value (474 kg/ha). Fertilizers plus manure application (100% NPK + FYM) increased available potassium by 14.8 per cent followed by recommended rate of fertilizer application at 150 per cent NPK (14.6%) as compared to control. During Kharif 2013 available K content of soil varied from a minimum of 359.29 kg/ha under 100 per cent N to a maximum of 412.74 kg/ha under 100 per cent NPK + FYM. Application of organic manure along with chemical fertilizers increased the available K content of soil significantly over control. There was a mining of potassium in all the treatments over its initial status of 474 kg/ha after 14 years of continuous cultivation. The decline in available potassium over initial value was highest in plots not receiving any manure or fertilizers.

Yield

Grain and straw yield of rice increased significantly with increasing level of fertilizers up to 150 per cent NPK (Table 4). Grain yield varied from 2350 to 5065 kg/ha amongst different nutrient concentrations alone and along with organics. Increase in grain yield over control (2.35 tons/ha) was 2.94, 4.34 and 5.06 kg/ha with the application of 50, 100 and 150 per cent NPK respectively. Among the treatments maximum grain (5.06 tons/ha) and straw yield (7.07 tons/ha) was obtained with 150 per cent NPK. This may be due to the higher available nutrients and optimum soil properties in the plots receiving higher dose (150% NPK) of inorganic fertilizers. Similar observations have been reported by Pandey et al (2009).

On the other hand incorporation of organic sources with inorganic sources of nutrition, the grain (4.85 tons/ha) and straw yield (6.56 tons/ha) of 100 per cent NPK + FYM was higher than 50 per cent NPK + GM and 50 per cent NPK + BGA. The integrated effects of fertilizer and farmyard manure, blue-green algae and green manure were noted to be more beneficial than the use of chemical fertilizers alone. Additional increase in grain and straw yield was registered due to the integrated effect of FYM with inorganic fertilizer. 100 per cent NPK + FYM gave the highest grain yield (4.85 tons/ha) and straw yield (6.56 tons/ha) compared to 100 per cent NPK treatment. Grain yield (4.10 tons/ha) with 50 per cent NPK + GM also gave similar results and comparatively higher grain yield was recorded in 100 per cent NPK (4.34 tons/ha). This indicates that more than half of the nutrients in fertilizer could be substituted with GM for the sustainable yield.

Table 4. Long-term effect of various treatments on grain and straw yield of rice crop

Treatment	Yield (tons/ha)	
	Grain	Straw
Control	2.35	2.68
50% NPK	4.04	4.77
100% NPK	4.34	5.55
150% NPK	5.06	7.07
100% NPK + Zn	4.13	5.51
100% NP	4.34	5.83
100% N	3.95	5.39
100% NPK + FYM	4.85	6.56
50% NPK + BGA	3.67	4.61
50% NPK + GM	4.10	6.55

CONCLUSION

The results suggested that the contribution of important soil quality attributes like organic carbon, available nitrogen, phosphorus and potassium is governing the soil quality indicators. Integrated use of inorganic fertilizers and organic manures resulted in higher growth parameters and maximum yield of rice. There was a build up in organic carbon and available nitrogen, phosphorus and potassium status of soil under combined application of organic and inorganic sources of plant nutrients. Thus the combined use of organic as well as inorganic sources of plant nutrients could be a sustainable option for optimizing the yield of rice.

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